Taming Large Models with Hawk and NeoEMF

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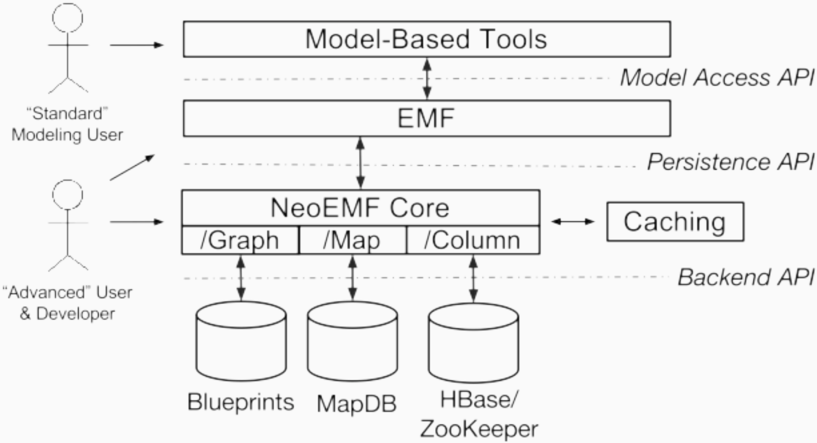
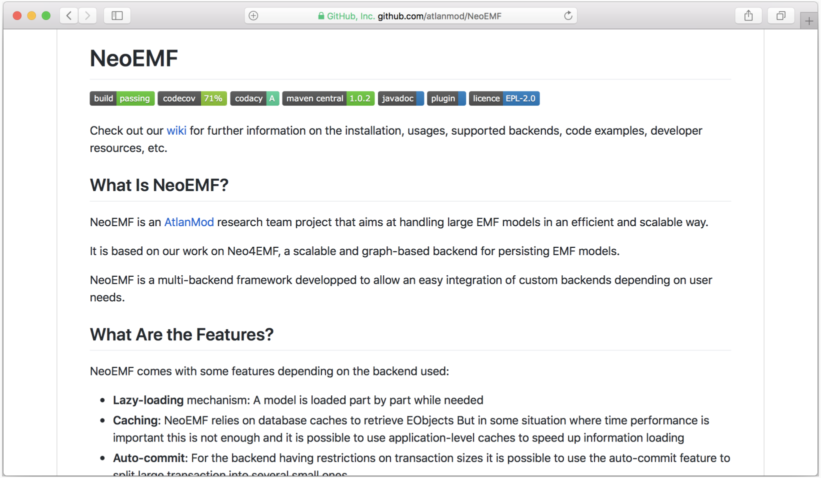
NeoEMF

NeoEMF: Architecture



NeoEMF: project website



NeoEMF

Check out our wiki for further information on the installation, usages, supported backends, code examples, developer resources, etc.

What Is NeoEMF?

NeoEMF is an AtlanMod research team project that aims at handling large EMF models in an efficient and scalable way.

It is based on our work on Neo4EMF, a scalable and graph-based backend for persisting EMF models.

NeoEMF is a multi-backend framework developped to allow an easy integration of custom backends depending on user needs.

What Are the Features?

NeoEMF comes with some features depending on the backend used:

- **Lazy-loading** mechanism: A model is loaded part by part while needed
- **Caching:** NeoEMF relies on database caches to retrieve EObjects But in some situation where time performance is important this is not enough and it is possible to use application-level caches to speed up information loading
- **Auto-commit:** For the backend having restrictions on transaction sizes it is possible to use the auto-commit feature to split large transaction into several small ones

- `https://github.com/atlanmod/NeoEMF`
- Open source project under the Eclipse Public License 2.0

NeoEMF Datastores [DSB+16]

- NeoEMF/Graph
  - Efficient model traversal using rich query language
  - Mogwaï framework (OCL to Gremlin translation)
- NeoEMF/Map
  - Fast access to atomic operations
  - Designed for EMF-API calls
- NeoEMF/Column
  - Transparent model distribution
  - Concurrent read/write
  - Distributed model transformations (ATL-MR)

NeoEMF Key Features

- Lazy-loading
- Compliant with EMF API
- Easy to integrate in existing applications
- EMF-Compatible code generation
- Advanced caching (+ prefetching) strategies
- Efficient XMI importer

Initialise a New Resource

1. Create a new URI to locate a file-based resource.
2. Create the resource.

```
URI uri = MyUriBuilder.builder().fromFile(new File("<db_path>"));

ResourceSet resourceSet = new ResourceSetImpl();
Resource resource = resourceSet.createResource(uri);
```

Save/Load Resource

1. Create a new configuration builder.
2. Save and unload resource.

```
ImmutableConfig config = MyConfig.newConfig()
.autoSave(50000)
.log()
.withOption("key", "value");

resource.load(config.asMap());

// Do something on the resource

resource.save(config.asMap());
resource.unload();
```

Modify existing resource

1. Load resource.
2. Modify contents.
3. Save resource.

```
ImmutableConfig config = MyConfig.newConfig()
.cacheContainers()
.cacheMetaclasses();

URI uri = MyUriBuilder.builder().fromFile(new File("db_path"));

Resource resource = new ResourceSetImpl().createResource(uri);
resource.load(config.asMap());

MyClass myClass = (MyClass) resource.getContents().get(0);
myClass.setName("NewName");

resource.save(config.asMap());
resource.unload();
```

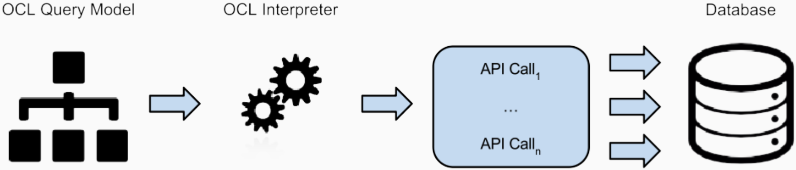
Demo time!

Let's import a Java model, save it in Neo4j and query the database.

Discussion

- Graph databases outperform relational ones for several navigation steps queries.
- But model loading operations only use 2 or 3 steps queries.
- If the use of the EMF API is the only concern, then a relational (or column) database storing BLOBs are a better solution.
- Impossible to compare with bigger models.

Discussion



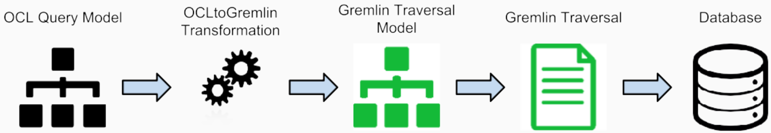
- Low-level model handling APIs
- Fragmented queries on the database
- Many intermediate objects

Mogwaï

Motivation

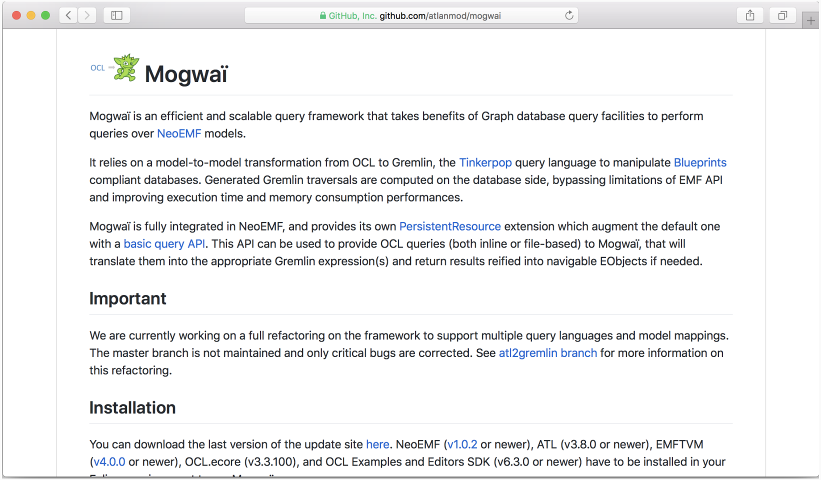
- Why don't we query directly the database?
- Manually writing database-level queries is hard
- Need to learn a new query language
- Database expertise vs. Modeling expertise
- Unknown model representation
- Solution: generate them!

Mogwaï: Architecture [DSC16]



- Generate graph database queries from OCL expressions
- Bypass modelling framework API
- Single execution of the query

Mogwaï: project website



Mogwaï

Mogwaï is an efficient and scalable query framework that takes benefits of Graph database query facilities to perform queries over NeoEMF models.

It relies on a model-to-model transformation from OCL to Gremlin, the Tinkerpop query language to manipulate Blueprints compliant databases. Generated Gremlin traversals are computed on the database side, bypassing limitations of EMF API and improving execution time and memory consumption performances.

Mogwaï is fully integrated in NeoEMF, and provides its own PersistentResource extension which augment the default one with a basic query API. This API can be used to provide OCL queries (both inline or file-based) to Mogwaï, that will translate them into the appropriate Gremlin expression(s) and return results reified into navigable EObjects if needed.

Important

We are currently working on a full refactoring on the framework to support multiple query languages and model mappings. The master branch is not maintained and only critical bugs are corrected. See atl2gremlin branch for more information on this refactoring.

Installation

You can download the last version of the update site here. NeoEMF (v1.0.2 or newer), ATL (v3.8.0 or newer), EMFTVM (v4.0.0 or newer), OCL.ecore (v3.3.100), and OCL Examples and Editors SDK (v6.3.0 or newer) have to be installed in your

- https://github.com/atlanmod/mogwai
- Open source project under the Eclipse Public License 2.0

Queries are expressed in OCL

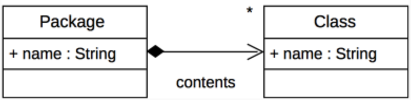


Figure 1: Simple Model

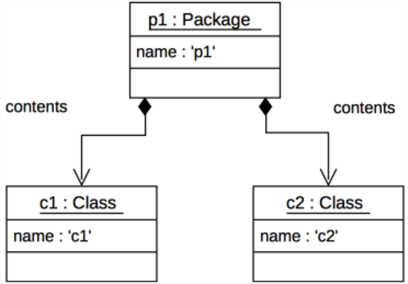


Figure 2: Model Instances

Package.**allInstances**() --returns p1

p1.contents --returns [c1,c2]

p1.contents→**select**(e | e.**name** = ’c1’

--returns c1

Model Persistence

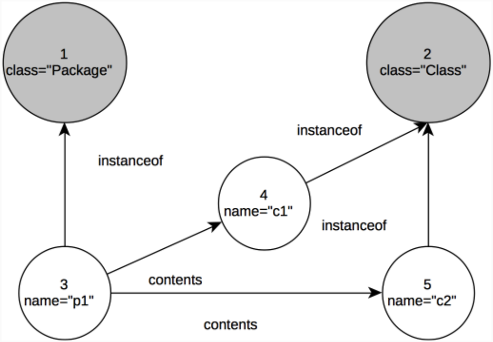
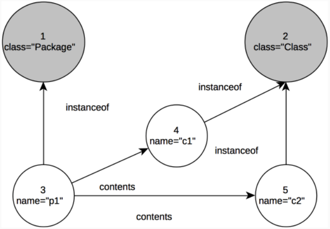


Figure 3: Model Instances Stored in Neo4j

Database Queries are expressed in Gremlins

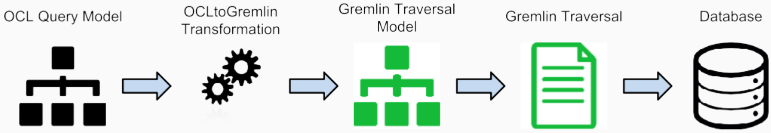
- Graph traversal DSL
- Composed of processing steps
- Generic query language for graph databases



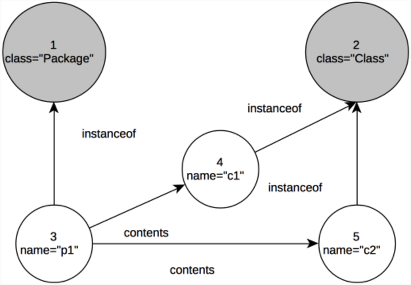
```
g.idx(''metaclasses'')[[name:''Package'']
.inE(''instanceOf'').outV // v(1)
g.v(3).outE(''contents'').inV // [v(4),v
g.v(3).outE(''contents'').inV
.filter{it.name = ''c1''} // v(4)
```

OCL Queries into Gremlin Traversals Translation

- Map OCL expressions to Gremlin steps
- Merge created steps into a (several) traversal(s)]

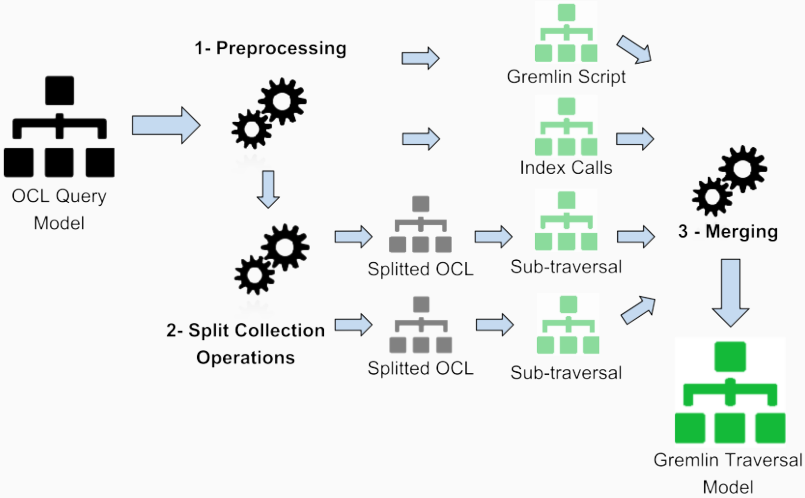


OCL Expressions to Gremlin Steps Mapping



OCL Expression		Gremlin Steps
Type	→	g.idx("metaclasses")[[name:"Type"]]
AllInstances()	→	inE("instanceOf").outV
collect(att)	→	att
collect(ref)	→	outE("ref").inV
select(cond)	→	filter{cond}
oclIsTypeOf(T)	→	outE("instanceOf").inV .transform{it.next() == T}

Merge created steps into a traversal



OCL Query Model

1- Preprocessing

Gremlin Script

Index Calls

Splitted OCL

Sub-traversal

2- Split Collection Operations

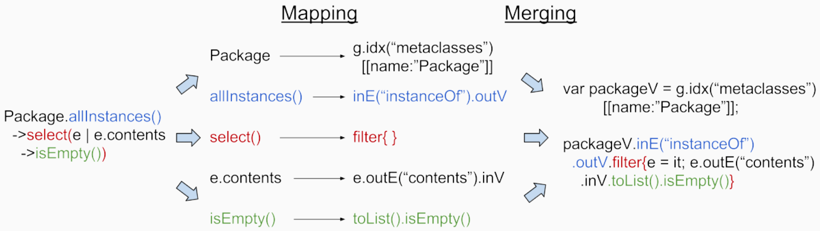
Splitted OCL

Sub-traversal

3 - Merging

Gremlin Traversal Model

OCL Transformation Example



Package.allInstances()
->select(e | e.contents
->isEmpty())

Mapping

Package → g.idx(“metaclasses”)
[[name:”Package”]]

allInstances() → inE(“instanceOf”).outV

select() → filter{ }

e.contents → e.outE(“contents”).inV

isEmpty() → toList().isEmpty()

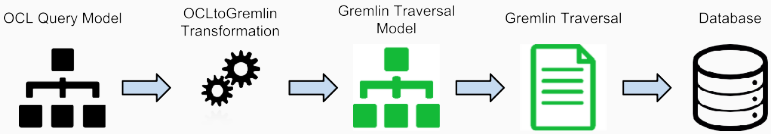
Merging

var packageV = g.idx(“metaclasses”)
[[name:”Package”]];

packageV.inE(“instanceOf”)
.outV.filter{e = it; e.outE(“contents”)
.inV.toList().isEmpty()}

Query generation and execution

- Delegates query computation to the database
- Returns graph elements to the persistence layer

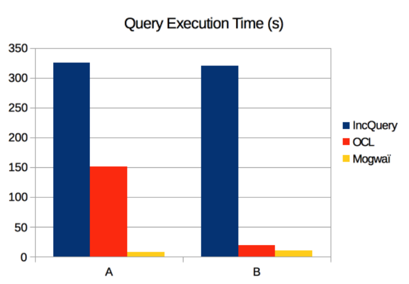


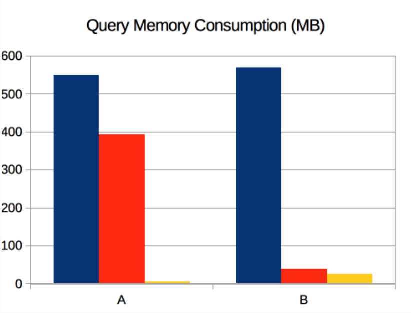
Demo time!

Let's query a Java model and find singletons.

Benchmark Results

- Model containing 2 million elements
- Up to 20 times faster than other query approaches
- Consume up to 75 times less memory





Conclusion

Model Persistence Frameworks

- Not designed to compute model queries efficiently
- Writing manually database-level queries is hard

Mogwaï

- Translates OCL queries into Gremlin traversals
- Positive results
- Not adapted to small models
- Needs to be integrated

References i

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